A MONOCHROMATOR PHOTOMETER FOR THE NEAR INFRARED REGION OF $0{\cdot}7\,\mu$ TO $1{\cdot}2\,\mu$

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The design of a spectrophotometer for the region $0{\cdot}7$—$1{\cdot}2\ \mu$ has been described. An insrument cf this design has been fabricated for laboratory use.

The region $0{\cdot}7\ \mu$ to $1{\cdot}2\ \mu$ is one of the neglected regions of the electromagnetic spectrum and is generally not covered by either infrared spectrophotometers or visible spectrophotometers. This is because of the little interest this region holds either for 'pure' spectroscopy or for industrial chemical analysis. However, this region is of exceptional interest for a class of I.R. devices which use the 'Image Converter Tube' for the detection of the targets illuminated by this part of the spectrum. It is further of much interest in biophysics and photographic industry. The determination of the transmission factors for various materials in this part of the spectrum is, therefore, one of the basic requirements for a successful development of the above devices. With a view to determining such data a suitable monochromator photometer has been built and calibrated in the laboratory. The design features are described below. The complete equipment is shown in Fig. 1.

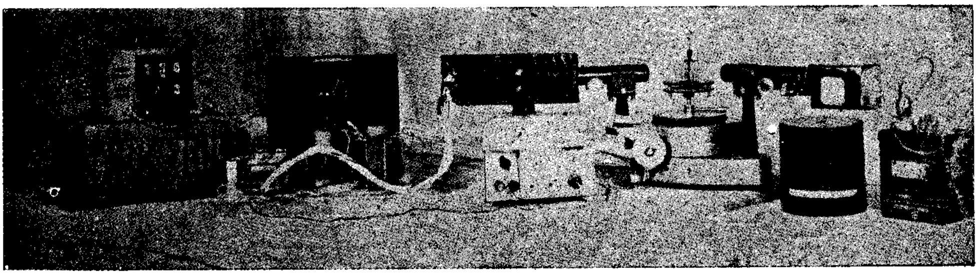

Fig. 1—Monochromator Photometer

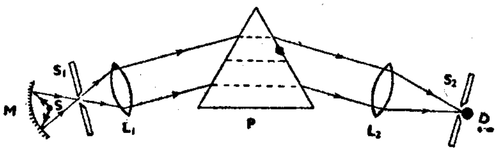

Fig. 2—Monochromator.

Monochromator

The monochromator (Fig. 2) consists essentially of a 60° prism P mounted on the prism table of an ordinary student spectrometer. Light from a source S (6 volts, 36 watts, autohead light lamp) is focussed on the slit S_1 of the collimator $S_1\ L_1$.

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The spectrum formed by the prism is focussed on the exit slit S_2 of width 0·4 mm (the eyepiece of the telescope L_2S_2 is replaced by the slit). As the telescope is moved, different wavelengths are focussed on the slit S_2 which are, in turn, detected by the detector D. The telescope movement is calibrated for different wavelengths.

Detector

The use of a photocell like 'CV 90' was not satisfactory as the current output is very small requiring amplification and a source of higher wattage. It will, in turn, result in problems of fluctuations of the intensity of the source with the main voltage. To avoid all these drawbacks, RCA photomultiplier tube (No. 7102), which has, a current amplification of 150,000 was used. Because of its great current amplification it was possible to make use of a 6 volts, 36 Watts lamp run on a 6 volts storage battery. The use of the storage battery ensured steady current output free from fluctuations.

A suitable powerpack was made to supply the required voltages to the different electrodes of the photomultiplier tube (Fig. 3.) It has a step-up transformer 220—750 VRMS and a double diode (5*R*4-*GY*) working as a fullwave rectifier with suitable filter-circuit. Voltage for each dynode and anode is supplied by spaced taps on a voltage divider across the rectifier output.

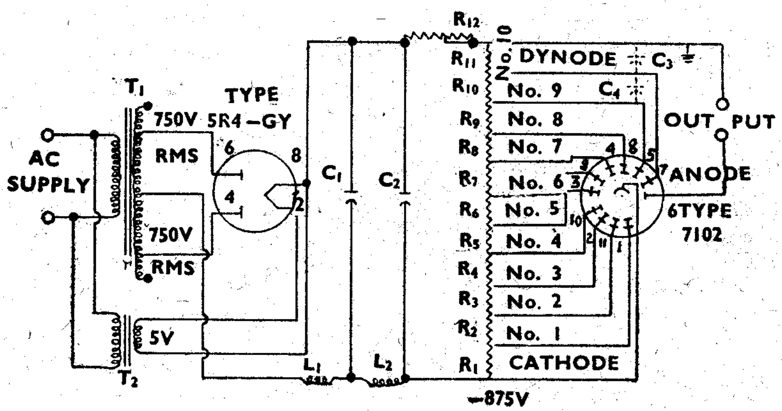

Fig. 3.—Detector. [The circuit constants are :

C_1, C_2—2 μf, 1000 volts (D.C. working)

L_1, L_2—8 m.H. chokes

C_3, C_4—8 μf electrolytic, 150 volts

R_1—39 $k\Omega$, 2 watts

R_2, R_3......R_{10}—18 $k\Omega$, 1 watt.

R_{11}—12 $k\Omega$, 1 watt.

R_{12}—200 k, 12 watts].

The resistances of the potential divider are so chosen that the current flowing through the potential divider is at least 10 times the total dynode current flowing through the divider in order to improve the regulation of the voltages given to different electrodes.

In order to obtain a steady output from the photo multiplier tube, the rectifier is fed with a voltage stabilizer giving steady 220 volts within ± 1 per cent. An ammeter is inserted in the anode circuit to read the anode current. This current should not exceed 10 μ amp. as given by the manufacturer. This can be controlled by adjusting the width of the collimator slit.

It is found preferable to ground the $+ve$ terminal and feed—ve voltage to the cathode, in order that the output signal is produced between anode and the ground. In this way we can prevent power supply fluctuations from being coupled directly into the signal output circuit.

DATA PRESENTATION

A PYE Scalamp Galvanometer having a sensitivity of $0 \cdot 063\ \mu$. amp./m.m. is connected in the photomultiplier tube circuit to measure the photo current. The variation in the photo current, known by placing the material under test before the detector, is taken as a measure of the absorption in the material.

CALIBRATION

The following procedure is adopted for calibrating the angular rotation with respect to the wavelengths incident upon the photomultiplier tube.

The angles of minimum deviation for the different lines of the mercury spectrum are measured in the visible region and the corresponding refractive indices of the material of the prism are calculated. From these the 'Cauchy's Constant' is determined. Using an 'Image Converter Tube' in the position of the eye piece, the angles of minimum deviation for a few lines in the region of $0 \cdot 7$—$1 \cdot 2\mu$ are determined and their wavelengths calculated from the earlier data. These wavelengths are compared with the data available from the wavelength tables and are found to agree within $\pm 50A$, which represents a satisfactory accuracy of the setting for the purpose for which the instrument is intended. Intermediary wavelength positions are determined by interpolation. This procedure gives the wavelengths incident upon the exit slit in terms of the rotation of the telescope. A drum with pointer is fixed to the fine motion screw of the telescope to facilitate rapid settings. The photomultiplier tube is now fixed in position.

The above equipment is found to give satisfactory results of about $\pm$ 1% reproducibility. The source is quite stable and free from fluctuations.

% TRANSMISSION OF MATERIALS

The instrument is first adjusted for the required wavelengths by rotating the telescope. Now the photo current is measured first without the material (say I_1) then with the material before the telescope and after the prism (say I_2). The percentage transmission of the material, under test, is then given by $(I_2/I_1) \times 100$. Adjusting the telescope in different positions the corresponding transmission at different wavelengths can be measured.

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